When do consumption tax policies work towards their goals? Evidence from a sweets tax reform*

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Abstract

The policy goal of excise taxes, such as soda taxes, is to reduce consumption. However, the effectiveness of taxes seem to vary and this could depend on the unknown role of the substitution with non-taxed alternatives. We study a sweets and soda tax scheme in Finland and it's multiple reforms to shed light on this issue. The reforms create variation in the closeness of the non-taxed substitutes enabling us to test the role of substitution in the overall responsiveness. We utilize credible control groups not affected by the reforms and have access to unique product- and week-level data on sales containing hundreds of millions of observations. Our findings show that in general the tax was fully passed through to prices. Intriguingly, we find that without very close non-taxed substitutes the sweets tax did not create any discernible demand responses, but the tax hike on sugary soda that

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left artificially flavored soda as the very close substitute without a tax hike created large demand responses. Our results suggest that the role of very close substitutes is crucial in assessing the welfare losses to consumption taxes.

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1 Introduction

Most countries apply excise taxes with the Pigouvian motivation to reduce consumption of goods deemed harmful, due to negative externalities the consumption of these goods creates. Increasingly popular such measures are related to sugary products, such as beverages or sweets, to improve public health and limit the constantly rising health care costs (for surveys see e.g. Andreyeva et al. 2010 and Cawley et al. 2019). At the same time most countries have value added tax (VAT) or retail sales tax schemes to collect tax revenue. The policy goals of these two consumption tax schemes differ, but depend on the same measure; to what extent the taxes affect consumption by either minimizing the impact on it in the case of the sales taxes or changing it to the desired direction with excise taxes. In theory we understand that these responses depend on the direct effect the tax has on consumption of the taxed good, and also the substitutability of the taxed good with other close, but non-taxed goods (see e.g. Hines 1999). Empirically we lack causal estimates on the role of closeness of non-taxed substitutes and the role of that in the total response, although some relating work exists on, for example, cross-border shopping (Cawley et al. 2019).

This paper shows that the closeness of non-taxed substitutes to the taxed goods plays a crucial yet previously understated role in determining the size of the response to consumption taxes. More specifically, we show that when products are quite similar and sold in the same stores, there are no detectable substitution effects, but when the products are very close substitutes, e.g. variants of the same brand, we estimate rather significant substitution effects. We analyze the price-incidence, effect on sales of products and the role of substitution therein of a sweets and soda tax scheme in Finland. We have access to extensive data of ca. 500 millions of observations and information on various taxed and non-taxed product-groups. Essentially for our purposes, multiple reforms changed the excise taxes on various product-groups and consequently left different products as the non-taxed substitutes, thus creating exogenous variation in the closeness of substitutes to the taxed products. We also develop direct measures of substitution and show how the

general responsiveness to consumption taxes is associated with this measure. The more distant substitutes operate as purer control groups in the analysis.

This paper contributes to the earlier literature in multiple of ways. First, the demand elasticities caused by excise taxes estimated in the earlier literature have a huge range of 0.05–1 for sweets and sugars and of 0.06–3.18 for soft drinks (Andreyeva et al. 2010). With multiple reforms creating large exogenous variation in the taxes for sweets, soda and ice cream, and leaving taxes of other grocery products unchanged, we are able to provide reliable reduced-form estimates on the size of the elasticity. We are able to demonstrate empirically the credibility of the comparison across groups with parallel pre-trends. We also have access to unique scanner-data with ca. 500 millions of observations. The data consists of the prices and traded quantities of all products from taxed categories and a set of similar non-taxed products. The large size of the data allows us to provide precise estimates. Moreover, our data source is a grocery store chain, the S-group, that is sufficiently large to represent the consumption patterns of all the Finns because the chain has a market share of about 45% of grocery markets in Finland.

Second, the institutional setting creates variation in the size of the exogenous variation as well as the closeness of substitutes that were not directly affected by the taxes. We also have variation that increases taxes from the introduction and subsequent increases of the tax as well as variation decreasing taxes from the abolishment of the tax for sweets and ice cream. All this allows us to provide clear answers on which factors the size of the response depends, the closeness of substitutes or the size or direction of the tax change. This further helps to understand under what kind of circumstances we might expect a large response to consumption taxes and under what circumstances a small response.

Third, we develop administrative data and survey-based measures of the degree of substitutability between different products. These are novel methods that apply to groceries, and potentially to a wider group of consumer products, measuring the substitutability across different products directly. We associate the demand responses to taxes with this measure separately by product-category. This third dimension of our setting contributes to a gen-

eral analysis of consumption systems and allows us to provide transparent reduced form results on the role of substitution in the presence of multiple products or markets in the spirit of Harberger's models (Hines 1999). We also demonstrate that a tax change has an effect on the non-taxed products, but only when they are very close substitutes.

The sweets tax policy we analyze was introduced in Finland as an excise tax on sweets, chocolates and ice creams in the beginning of January 2011. The tax rate amounted to 0.75€/kg for solid tax-liable products. In addition, an existing tax on drinks (soft drinks, juices and waters) was raised from 0.045€/l to 0.075€/l. There were subsequent changes of the tax scheme we utilize: an increase of the tax in January 2012, an increase of the tax only for sugary drinks in 2014 and abolishing the tax for sweets and ice cream in 2017, but not for drinks. Importantly, whether a product is subject to the tax depends on its customs classification, and as a result we have various control groups not affected by the tax. For example, chocolate is subject to the tax while chocolate biscuits are not. Moreover, because the sweets tax depends on weight or volume of each product, the tax-induced price changes vary with the weight-to-price or volume-to-price ratios creating additional exogenous variation in the tax.

Our results show that the sweets tax was in most cases either fully or over-shifted to prices. We find two sources of heterogeneity in the pass-through, although in all cases the pass-through is quite close to full. First, the larger the impact of tax is relative to the pre-reform price the smaller the pass-through to prices. For example, the tax increase for soda was much smaller relative to pre-reform prices than for ice creams in both the 2011 and 2012 reforms, and we find much larger pass-through relative to the full pass-through for soda than for ice cream. Second, we find a modest level of asymmetry. The tax increases in 2011, 2012 and 2014 led to at least full pass-through in almost all cases, but abolishing the tax in 2017 for sweets and ice cream led to less than full pass-through, also in statistical terms. This shows a modest degree of asymmetry in the pass-through, and is consistent with the analysis of Benzarti et al. (2020) for VAT.

The results for quantities sold (and presumably consumed) show two very

distinct results. First, general tax changes that affected all products within a product category similarly do not affect the sales for sweets, ice cream or soda in a statistically discernible manner. These tax changes were the increases in 2011 and 2012 as well as abolishing the tax in 2017 that applied with the same weight or volume based rule equally to all products within ice creams, sweets and in 2011 and 2012 to drinks. As noted above, these tax changes led to sharp increases and decreases in prices, but because the same reforms did not lead to significant changes in sales quantities, the implied demand elasticity is close to zero. Second, the tax increase for sugary soda and other sugary drinks in 2014 that left non-sugary drinks unaffected from the same product categories led to a dramatic and quite sudden shift in consumption towards the non-sugary drinks. The 2014 reform affected prices with a similar magnitude than the other sweets tax reforms suggesting another explanation for the difference between our two very distinct demand response results.

We then turn to analyzing which mechanism could be consistent with the set of results explained above. Our hypothesis is that the role of substitution plays an important role understated in earlier literature: for the tax to create changes in demand there needs to be a very close substitute to taxed products not directly affected by tax changes. Under this explanation excise taxes do not create demand responses when there is no very close non-taxed substitute available, although there would be a large change in prices. By examining the products that are presumably the closest non-taxed substitutes in different reform, this explanation seems plausible. In the 2014 reform that increased taxes for sugary drinks some sugary drinks have a very close non-sugary alternative: for example Coca cola was subject to a higher tax while Coca cola zero was not. In the other sweets tax reforms the non-taxed alternatives are relatively close substitutes but come from different product categories and as a result are not quite as close, for example chocolate was subject to a higher tax while chocolate cookies were not.

To study the substitution hypothesis more systematically, we develop measures on the closeness of substitution and then relate these measures to the demand responses in different reforms explained above. This part of the analysis is still under progress, but we already have some results. Our favorite

measure for the substitutability is the most direct one we could imagine: conducting a survey to consumers and asking about how close substitutes the respondents think different products are. Specifically, we ask in the survey how close substitutes a pair of products are in the scale of 0 to 10 with a higher number indicating closer substitutes, and then repeat that question for many pairs. When averaging the responses across product categories, as a result we have a substitution matrix. In that matrix we have a number in the scale of 0 to 10 for each pair of product categories. The preliminary results support the hypothesis above that sugary and non-sugary drinks, especially soda, have a higher substitution index between each other than other pairs where one of the products is subject to the sweets tax and other is not. Aligning our estimates on the effect of sweets tax on quantity consumed with the substitution index to closest non-taxed alternative, we get a pattern as a result of a sideways hockey-stick; excise taxes have no impact on consumption until they cross a threshold of very close substitutes. Then the estimated demand elasticity is close to unity.

We also utilize the information on the substitutability of different products by having more distant substitutes as a purer control group when we estimate the impact of the sweets tax increase for the sugary drinks on the group directly subject to the tax and also on non-sugary drinks that are not subject to the tax increase but are close substitutes to the taxed products as exlpained above. Supporting the substitution effects hypothesis, we find that the sales of sugary drinks declined while the sales of non-sugary drinks increased by almost similar amount. The effect on sales of both groups combined is negative but quite modest in absolute size compared to the estimates on the two groups separately.

An increasingly active literature has analyzed the demand elasticities that are relevant for welfare losses created by consumption taxes. The literature has found quite large range of elasticities making the policy recommendations harder. This study contributes to this literature by showing one potential reason for diverging elasticity estimates, the closeness of non-taxed substitutes. For example, Kosonen (2015), Harju et al. (2018) and Benzarti et al. (2020) study demand responses created by VAT, which is applied to broad

product categories with the same tax rate. Supporting the essential role of close non-taxed substitutes that are not available often with VAT, these studies find very modest demand responses. In contrast, studies on cross-border shopping of beverages from a jurisdictions that have implemented a soda tax to a neighboring jurisdiction without the tax show more distinct changes in consumer behavior, as summarized by e.g. Cawley et al. (2019). Similarly, Harju et al. (2020) study the impact of car taxes on demand for cars. These studies find more significant demand responses, and this is also consistent with the substitution story, because the non-taxed alternatives in these cases are very similar or even the same product purchased from elsewhere, and thus very close substitutes to the taxed products.

Previous literature has also studied the price, consumption and health effects created by excise taxes on beverages. Using the state-level variation in the US, Fletcher et al. (2010) document that while taxing soft drinks decreases the consumption, it increases calories from whole milk consumption and has no impact on health outcomes, also supporting the substitution story. Berardi et al. (2016) study the soda tax pass-through in France using a data set similar to ours, with outlet-level super market prices. However, they only focus on prices. They find that it took six months to reach the full pass-through and that the pass through differed by the retailing group and brand, and remained incomplete in the case of flavored waters.

Using the city-level average prices, Grogger (2015) documents overshifting in the prices as the response to the introduction of soda tax in Mexico. Similarly, Bergman and Hansen (2016) find that excise taxes are overshifted to sodas when analyzing the Danish micro-data. They also document that pass-through rates are asymmetric so that tax increases are overshifted more than tax cuts. In contrast, Cawley and Frisvold (2017) document a pass through of 43% in a context in which a tax on sugar-sweetened beverages was levied only within a rather limited geographic area, providing some evidence about the impact of the competition on the pass-through.

The paper proceeds as follows: Section 2 describes the institutions more precisely, section 3describes the data, and Section 4 shows the results. Section 5 concludes the study.

2 Institutional background

On 1 January 2011, Finland introduced an excise tax on sweets, chocolates, ice creams, chewing gums, and some other naturally or artificially sweetened products and raised the existing excise tax on soft drinks[1]. Together, these excise taxes are called the sweets tax. There were two subsequent tax rate increases in 2012 and in 2014 while the tax was abolished for sweets and ice cream from 1 January 2017.

The sweets tax is based on custom categories, within a category the tax was assigned based on weight or volume of the package. The tax was thus not based on the sugar content of the product. As a result, some products are taxable while other, quite similar ones are not. For example, cookies, sweet pastries or snack bars are not tax liable while chocolates and candy bars are. Moreover, since the tax is tied to the weight or the volume, the tax impact varies across the products within a taxed product category depending on their weight or volume.

The previous excise tax rate on the relevant liquids was 0.045 €/l. Since 1 January 2011, the sweets tax rates amounted to 0.75 €/kg for the solid taxable products and 0.075 €/l for the liquid taxable products. The rates were subsequently increased so that, from 1 January 2012 onwards, the valid rates were 0.95 €/kg for solid taxable products and 0.11 €/l for liquid taxable products. The 0.95 €/kg for sweets and ice creams was abolished from 1 January 2017, but the tax on drinks was not.

The tax rates were further changed on 1 January 2014 so that the tax rate for the liquids with a sugar content higher than 0.5 g per 100 g or 100 ml was raised to 0.22 €/l. The purpose of this differentiated tax change was to channel consumption into sugar-free products. The definition of the sugar-free liquids was based on the regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods. An existing legal definition for sugar-free products decreased the administrative burden as the companies were

[1]These products are also subject to the reduced VAT rate (13% from July 2010 until December 2012 and 14% since January 2013). The VAT is calculated based on the sum of the price and the excise tax.

already familiar with the definition and monitored for its appropriate use. Furthermore, it was very clear whether a product would fit the definition since the products below the threshold value were clearly sugar-free, such as waters, or artificially sweetened so that there was no sugar involved in any manufacturing phase.

Any sweets, ice cream or soft drinks used for manufacturing sweets, ice cream, soft drinks or other food products or exported to the other EU countries by a registered storage keeper are untaxed. Also untaxed remain any sweets or soft drinks that are used for manufacturing medicine, alcoholic drinks, clinical nutritional products, infant formulas, children's foods or weight-loss products, provided such products comply with the definitions of the respective laws. Finally, small-scale production is also exempt from the tax (Laki virvoitusjuomaverosta 17.12.2010/1127).[2]

The sweets tax is carried out whenever products are provided for the consumption purposes from a tax-free warehouse or imported to Finland. Manufacturers, wholesale sellers and importers are the parties liable to tax. However, it is possible to export products from a tax-free warehouse without incurring tax liabilities. The Finnish Customs Office is responsible for carrying out the sweets tax collection and overseeing the producers.

There is no data on sweets smuggling but anecdotally it has been deemed unimportant. Since the law change was implemented, the Finnish Customs Office has paid special attention to inspecting companies that are tax-liable (Sokeriverotyöryhmän loppuraportti 2013).

3 Data

Our data source is a large Finnish retail-chain called the S-group, and the data consist of their product-specific sales figures of all the relevant food products at the outlet level aggregated to the weekly level from the last week of 2009 to the end of 2018. These outlets are evenly located all across the country and there are 1,077 of them. The total data consists of ca.

[2]Small-scale production refers to independent producers that annually produce for the consumption purposes at most 10,000 kg of sweets or of ice cream or 50,000 l of soft drinks.

500 millions of observations. The market share of the S-group in the grocery markets in Finland is roughly 45%, making the sales data quite representative of the consumption behavior in Finland, although it is not a random sample of stores.

The data consists of taxed and non-taxed product groups. In the taxed group we have: sweets (chocolates, candy bars and assorted candies, chewing gums), ice creams, drinks (soft drinks, juices, juice concentrates, waters). In the non-taxed group we have: cookies, cakes, sweet and salty snack bars or pastries, sugars, honeys, and syrups.

The data include the product name (e.g. Angry Birds Red Bird), its custom category (e.g. 2106), its detailed product category (e.g. fruit xylitol chewing gums with a package size larger than 60 g), its net consumer package size[3] in kilograms or liters (e.g. 0.07 g) and whether this refers to liters or kilograms. The data also include the total number of the items sold and the monetary value of the items sold as well as information on the number of the discounted items and the total monetary values of these discounts. All the product-specific information is summed up for each outlet for each week. Finally, there is data on which chain each outlet belongs to and which region it is located in.

All the monetary data is in euros. There is no data on the wholesale prices or the identity of the producers. Based on the product names, the product categories and the custom categories, we impute which products are taxable and which are not. The wholly taxable custom categories are sweets without cocoa (1704), chocolate and other food items with cocoa (1806), ice cream, popsicles, and other iced products (2105), non-fermented or non-alcoholic juices (2009), diverse food products (2106) that consist mainly of juice concentrates, unflavored or unsweetened waters (2201), flavored or sweetened waters or other non-alcoholic beverages not in the group 2009 (2202), and other fermented beverages or mixtures (2206). The partially taxable custom categories are products similar to 1704 but not sugared (2106), consisting of xylitol chewing gums, stevia-sweetened or sugar-free candies and syrups.

[3]The definition refers to the package size net of packaging and non-edible ingredients, making it equivalent to the legal definition of the excise tax base.

The untaxed custom categories are plain bread, cakes, cookies and biscuits and other pastries (1905), food products made from grain or grain product by swelling or baking (1904), cane and beet sugars and chemically clean sucrose (1701), other solid sugars (1702) and natural honey (409) (Laki virvoitusjuomaverosta 17.12.2010/1127).

Table 1 describes the data. The first two columns give the average price and quantity sold per week as well as other statistics for these upper panel for taxable products and lower panel for the control group products. N is the number of observations in the data and N*pieces is the total number of products sold underlying the data, derived by multiplying counting how many products were sold in each store per week and aggregating over the stores. The last three columns describe similar statistics in three different sub-groups of taxable products.

When imputing the mechanical full tax pass-through, we take into consideration the fact that the data consists of the retail prices, including the VAT. We impute the base price for each product as its mean price in November and the two first weeks of December prior to a tax change. Based on this product-specific base price, we impute the full pass-through as follows and take the logarithm over it:

$$\ln\left(p_{full,it}\right) = \ln\left(\left(1+\text{VAT }_{t}\right)\left(\frac{\text{base price}_{it}}{1+\text{VAT }_{t}} + \text{new ex. tax }_{it}\text{-old ex. tax}_{it}\right)\right) \tag{1}$$

No excise tax was carried out for the solid products prior to 2011 so their old excise tax rate was 0€ in January 2011. In contrast, soft drinks, juices and other similar drinks were excise tax liable even prior to 2011, albeit at a lower rate of 0.045€/l. In January 2011, the respective excise tax rates were raised to 0.75€/kg and to 0.075€/l. In January 2012, the respective excise tax rates were raised to 0.95€/kg and to 0.11€/l. Finally, in January 2014, the excise tax rate for the liquids exceeding a threshold value of sugar was raised to 0.22€/l. The foodstuff is subject to reduced VAT rates, which amounted to 13% from July 2010 until December 2012 and 14% since January 2013 (Laki virvoitusjuomaverosta 17.12.2010/1127). The logarithms of the

product-specific pass-through rates are then averaged over for the relevant product group (ie. all the products, solids only etc.).

As the tax is added to the volume prices, cheaper the product, larger the tax impact of the 2011 and the 2012 tax reforms. In contrast, the differential tax impact of the 2014 reform was not related to the previous volume price but to the sugar content.

4 Results

We first examine the impacts of the sweets tax on prices and quantities in graphical event-study framework. The idea is to examine the trends between the group of products facing tax changes directly and comparison groups not facing the tax changes but resembling the first group before and after the reforms. We are not defining the groups as treatment and control in the traditional sense, as our goal is to see which all products are affected through substitution effects even when they are not directly affected by tax changes. The graphs are based on an estimation of the following equation for the logarithms of various outcome variables y_{it}:

$$\ln(y_{it}) = \sum_{t=-\underline{T}}^{\overline{T}} \beta_t time_t + \mu_i + \epsilon_{it}, \tag{2}$$

where $time_t$ refers to a set of either week or month indicators. $\underline{T}$ refers to the starting of the examination interval, for example beginning of 2010, and $\overline{T}$ to the end of the examination interval, for example the end of 2013. μ_i refers to product-outlet i fixed effects and ϵ_{it} is the error term. The outcome variables y_{it} consist of unit price, volume and number of products sold. The volume refers to kilograms or liters, depending on the product. The estimations are clustered at the product-outlet-level. In order to remove the seasonal variation of the volumes and number of products sold, we use the residuals from a regression that regresses the respective quantity variable on the product category-calendar month effect. The product categories are at the very precise level and there are 447 of them in this sample.

All the graphs are normalized with the coefficient of the last time obser-

vation before the first reform studied.

Figure 1 presents the development of prices around the 2011 and 2012 reforms for all treated and control products pooled. The figure shows that treatment and control group prices follow the same trend in the year before the reform. Then at the reform the treatment group prices exhibit a clear increase. The prices do not jump immediately to the new level, but rather the increase is gradual over the period of three months. The prices end up at a higher level than what the mechanical full-pass through, marked to the figure with the horizontal purple line, would have indicated. But because the control group prices also increase during the same time interval, it seems that the net effect to treatment group prices is about full pass-through. The development of prices is slightly different in the 2012 tax increase. The prices in the treatment group jump within two weeks to the new level after this reform. Moreover, it seems that the net price increase was higher than what full pass through would have implied.

To provide some estimates for different subcategories Figure 2 presents the development of prices separately for ice creams, soft drinks, sweets and chocolates (as a special category of sweets). The general time-pattern in these sub-groups is quite similar than the average pattern for all goods. The two notable exceptions are ice creams and soft drinks. Ice creams are an exception since the prices increase by less than the amount of the mechanical full pass-through in 2011 and by the full pass-through in 2012. This arises possibly due to the fact that the excise tax was larger relative to pre-reform prices among ice creams than among other taxed products. They tend to weigh more than other solid products and the tax impact increases with the weight. Soft drinks had the opposite feature to ice creams. For them the tax increase over the pre-existing tax was small relative to the pre-reform prices, but the pass-through seems to be more than full.

Figure 5 presents the over time development of quantities for solid products. The figure was seasonally smoothed by taking away the typical month-effect by regressing log volumes resp. log number of items sold against four-week periods (e.g. the first four week of January) and then taking residuals from these. This was necessary because of the heavy seasonality of the sales

of many products. The figure shows very clearly that the control and treatment groups develop on the same trend both before and after the 2011 and 2012 reforms. Thus, quite convincingly the reforms had no impact on the quantities. Thus, it seems that consumed quantities do not seem to change due to the sweets tax induced price hikes. This suggests that the demand elasticity with respect to price is close to zero in this case.

Figure 6 shows the development of volumes of soft drinks relative to their control group. The pre-reform trends do not develop quite as nicely in parallel in this case, but overall it seems to distinguish any clear effect after the reform either. Figure 7 presents the same four sub-groups as in the price analysis. The sweets and chocolate are quite similar than the overall analysis for solids. Ice creams and soft drinks (the same figure as above) have the same feature that their pre-trends are somewhat messy, but overall no clear impact of the reform is visible. The messy trends could be due to seasonality that we could not take into account.

We also analyze the abolishment of the sweets tax from the beginning of 2017. The prices are shown with the same method and for the same groups as above, but for the 2017 reform in Figure 3. Again, there is an immediate and large price response to the reform. However, on average the prices declined by less than what the full pass-through would have been, which suggests some modest asymmetric pass-through by comparison to the tax introduction results. The sub-group analysis in Figure 4 show that for sweets the pass-through seems to be full, but for the other categories slightly less.

The quantities develop again quite smoothly over the 2017 reform, shown in Figure 7. Although there are some noice in the series, it seems that any responses are quite modest at best. This observations builds support for the idea that the demand elasticities in this case might be rather low.

We analyze the impact of the sweets tax reforms with a differences-in-differences (DiD) framework as well. This analysis quantifies the average impact of the reforms studied graphically above. We estimate the following equation.

$$\ln(y_{it}) = \alpha_i + \beta_1 1\left(After * Target\right) + 1\left(After\right)_t + 1\left(Target\right)_i + \mu_t + \epsilon_{it}, \quad (3)$$

where $1\left(After\right)_t$ is an indicator taking value one for after the reform period, $1\left(Target\right)_i$ is an indicator taking value one for the products in the taxable categories or the substitute categories of interest, $1\left(After * Target\right)$ is the interaction of the two indicator terms and thus β_1 the main coefficient of interest for product i and period t. $\ln(y_{it})$ is the logarithmic outcome variable, either unit price or the volumes or items sold. We may include product level fixed effects α_i in which case the indicator for the treatment group is not included in the regression. We include in the regression flexible time trends μ_t as indicators for each time period. ϵ_{it} is the error term.

Table 2 shows the results for prices of the 2011 and Table 3 of the 2012 reform. The results indicate that the average pass-through was full for the 2011 reform. Moreover, the table confirms the intuition from the graphical analysis that for ice creams the pass-through was less than full and for soft drinks more than full. In the 2012 reform the average pass-through was more than full. A possible general pattern from these observations is that the smaller the mechanical impact of the tax on prices, the higher is the pass-through and vice versa, when the impact of the tax is higher the lower is the pass-through. In numbers it seems that the sweets tax were increased by about 10% after the two reforms relative to the control group.

Table 4 shows the differences-in-differences estimate for quantities. The regression takes as the pre-period year 2010 and as after-period 2011 to 2013. Thus the regression combines the 2011 and 2012 tax increases. All the coefficients are close to zero. The preferred estimate is in column (2), which combines reforms 2011 and 2012 and adds product-level fixed effects. The estimate is -0.003 and is statistically not significantly different form zero with quite tight confidence intervals. Thus, we conclude also based on this estimate that the reform had no impact on the amount of sweets sales.

Table 5 show the DiD estimates for quantities in the 2017 reform. The estimates are non-zero but note that by switching the control group from all

to sweet pastries, the coefficient switches sign. Thus, again these estimates can exclude any large quantity responses, and our best guess is that the demand elasticity suggested by these estimates is close to zero.

We next turn to studying the 2014 tax increase for sugary soda that left the tax on sugar-free soda unchanged, the 2014 tax change doubled the tax rate for sugared liquids from 0.11 €/kg to 0.22 €/kg. Figure 9 shows that the consumer prices responded immediately and increased rapidly by an amount of mechanical full pass-through immediately after the reform. The figure also shows the prices of sugar-free liquids and the prices of a control group. Relative to the control group it seems that the sugar-free drinks exhibit initially some price increase after the reform, but this subsidizes and their prices return to the control group level.

Figure 10 shows the quantity evolution of sugary versus sugar-free drinks and Figure 11 the same comparison between the sugary and sugar-free soft drinks. The figures show that the two groups are on a parallel trend prior to the reform and that there is a clear separation between the sales of the two groups precisely at the time of the reform. Figure 12 adds to the previous figure a third group, a common control group consisting of ice cream, sweets and chocolates. The control group illustrates that at the 2014 reform the consumption of sugary soda declined and the consumption of sugar-free soda increased. This suggests that there was a substitution effect from sugary soda to sugar-free soda.

Table 6 shows the DiD regression results of the 2014 reform for prices. The estimate in column (1) for all sugary drinks shows an increase of 9.7%, which more than full pass-through. The estimate for sugary soda in column (3) is 7.5% which is almost exactly full pass-through.

Table 7 shows the quantity regressions for the 2014 reform. Columns (1) through (3) are for all drinks and columns (4) through (6) focus on soda only. Column (1) shows that relative to a common control group the consumption of all drinks declined by about 1,6%. When separating the effects between sugary and sugar-free drinks, the effects are clearer and opposite: column (2) shows that the sugary drinks exhibit a decline of 4.2% while sugar-free drinks increase by about 5.6%. The total effect is negative because the group

of sugary drinks is larger than the group of sugar-free drinks. The effects are to the same direction but more pronounced for soda. The total effect in column (4) shows a decline of 4.1%, and the consumption of sugary soda seems to have declined by 7.3% while the consumption of sugar-free drinks seems to have increased by 3%. We have to note that the division between the main and substitution effects is quite sensitive to the choice of the control group, and do not want to take the exact point estimates as certain. But in general we observe that there was a total effect on consumption of drinks due to this last reform and that there was a clear substitution from sugary drinks to sugar-free drinks. This last observations is also capable of explaining why we see such clear consumption effects here while earlier reforms having similar impact on prices did not have a clear impact on consumption of sweets or drinks for that matter.

4.1 Mechanisms

The summary of results thus far is that we observe that prices increase on average about 10% after the two tax increases in 2011 and 2012 relative to the control group. We also observe roughly similar magnitude of price increases in the 2014 tax reform for sugary liquids. Thus, the price results indicate that taxes increased prices in the 2011 and 2012 similarly as in the 2014 for sugary liquids. The quantity results are very different in these three reforms, though. In the first two reforms we could not find any significant quantity reductions, which would suggest a demand elasticity with respect to price of zero. The result is clearly very different from the quantity response in the 2014 reform. In that reform the quantity response was clearly negative. In fact, for sugary soda the response seems to imply a demand elasticity of one. The 2017 tax abolishment for sweets and ice cream confirms the result that for these groups the demand elasticity seems to be from low to zero.

We think that the most obvious mechanism that explains the above summarized results is that substitution to non-sugary soda was much easier than substitution between candies and cookies. We have developed a survey that could shed light on this hypothesis. The survey presents pictures of pairs of

products to consumers and for each pair of product asks how substitutable between each the consumer sees the products. An example of how the survey looks like (in Finnish) is presented in Appendix A, Figure A.1. The results of the survey can be used to calculate an average substitution index between taxable products and their closest non-taxable substitutes (or non-tax increase products).

One observation is that sugary soda is very similar to artificially flavored soda. For example, big brands like Coca Cola and Pepsi have both products in the market, those sweetened by sugar and those sweetened by artificial flavoring agents, and they seem to advertise the these products as equally enjoyable. Our very preliminary survey results confirm that the sodas are relatively the closest substitutes across different product pairs tested out. For other products facing tax increases the closest non-taxable products are more distant substitutes, like sweets versus sweet pastries or cookies.

We then test the idea whether the survey based substitution index explains the results. Figure 13 shows differences-in-differences estimates for the quantities purchased of different groups of products organized from lowest to highest substitution index number. Clearly the demand decreases much more due to tax hike only when the substitution index reaches a relatively high number, for different sodas. Thus, this preliminary result suggests that the consumption responds to taxes only when the non-tax increase substitute is a very close one.

If the above assertions are true, it seems that the feasibility of substitution is a more important factor explaining demand responses that small variations in price. Thus, although substitution possibilities are recognized in the literature, their significance is not highlighted as much as it should.

5 Conclusions

We study the pass-through and quantity elasticity of the sweets tax introduced in Finland in 2011 and subsequent tax increases in 2012 and 2014. Our very findings show that the sweets tax was fully passed through to prices in the 2011 reform and over-shifted in the 2012 reform that was a smaller in-

crease in the tax.

We find that the tax introduction in 2011 and tax increase in 2012 did not affect the consumption of sweets, ice creams or soda at all. In contrast, we find that the 2014 tax increase for sugary soda did reduce the consumption of sugary soda. This reform left the tax of sugar-free soda, a close substitute, unchanged. We indeed find that there was substitution towards sugar-free soda.

This substitution effect could explain the different demand effect in the 2011 and 2014 reforms, in the former reform close substitutes that were not treated with a tax increase were not available. This suggests that when designing sin tax reforms the availability of healthier and close substitutes needs to be kept in mind.

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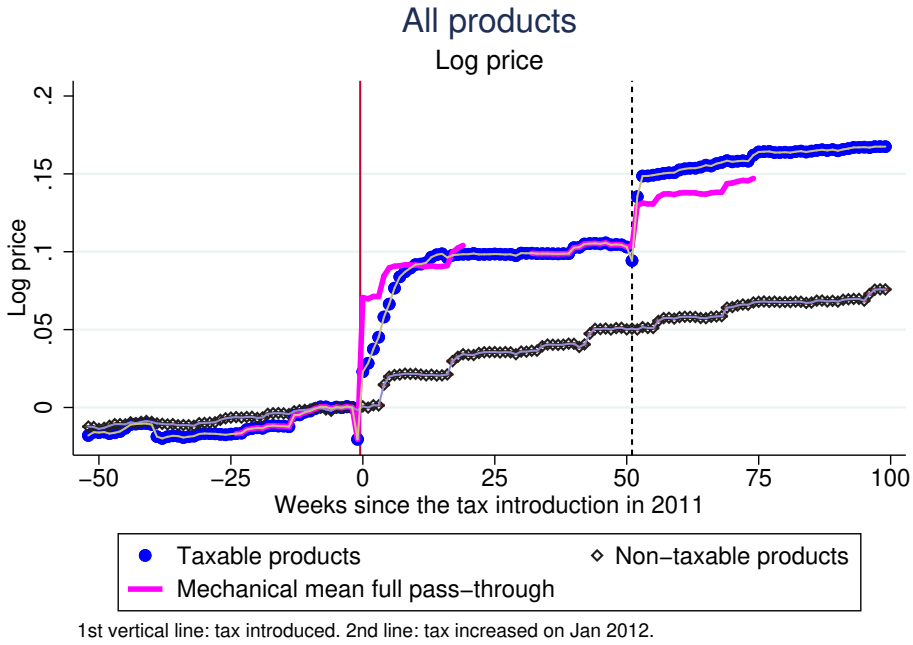
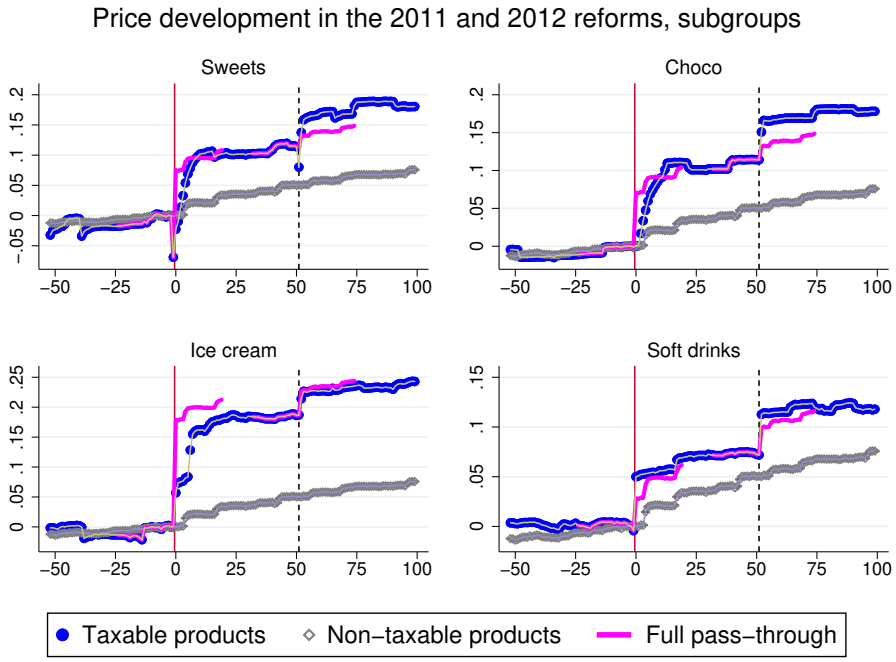
Figures

Figure 1: Development of log unit prices in the 2011 and 2012 reforms



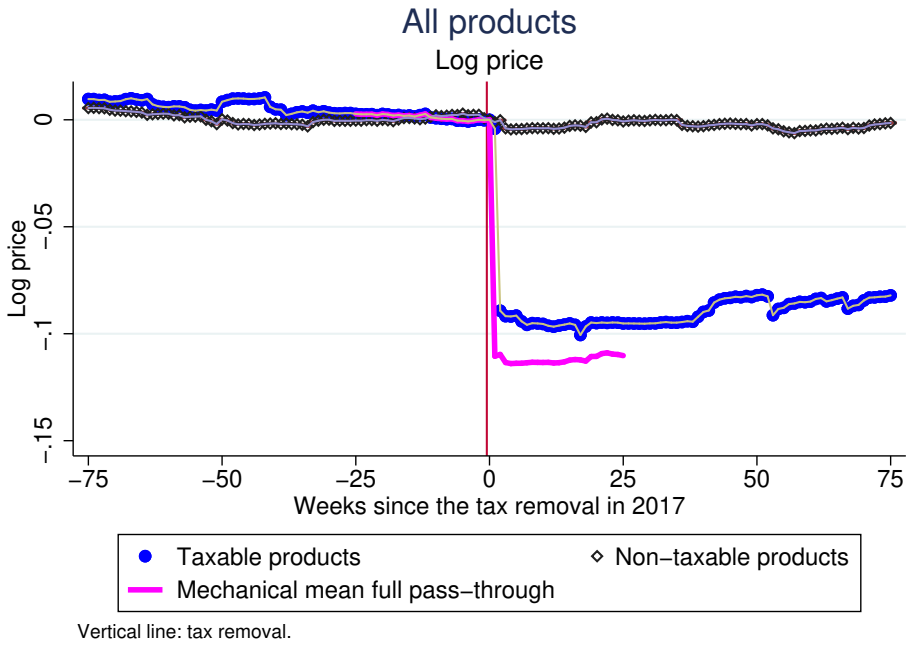
Note: The figure shows regression coefficients for week dummies from regressions of log unit prices with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Mechanical full pass-through in solid pink line shows how taxable product prices would have developed with full pass-through of tax change to prices, had they otherwise followed the prices of non-taxable products post-reform. Vertical lines at 2011 and 2012 reforms. The series are normalized to zero at two weeks prior to 2011 reform.

Figure 2: Development of log unit prices, various sub-categories of taxable products in the 2011 and 2012 reforms



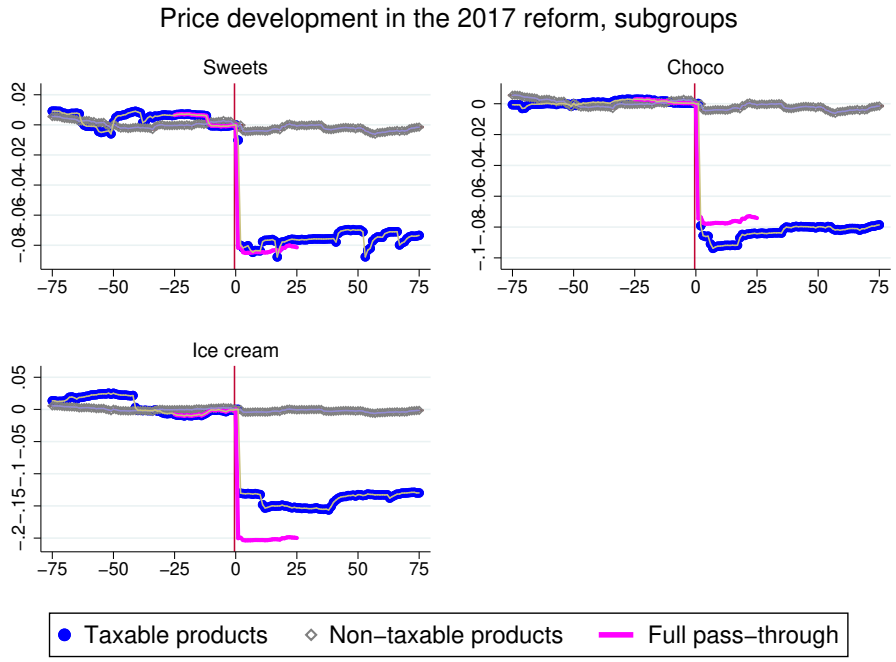
Note: The figures show regression coefficients for week dummies from regressions of log unit prices with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Mechanical full pass-through in solid pink line shows how taxable product prices would have developed with full pass-through of tax to prices, had they otherwise followed the prices of non-taxable products post-reform. Vertical lines are at 2011 and 2012 reforms. The series are normalized to zero at two weeks prior to 2011 reform.

Figure 3: Development of log unit prices in the 2017 reform



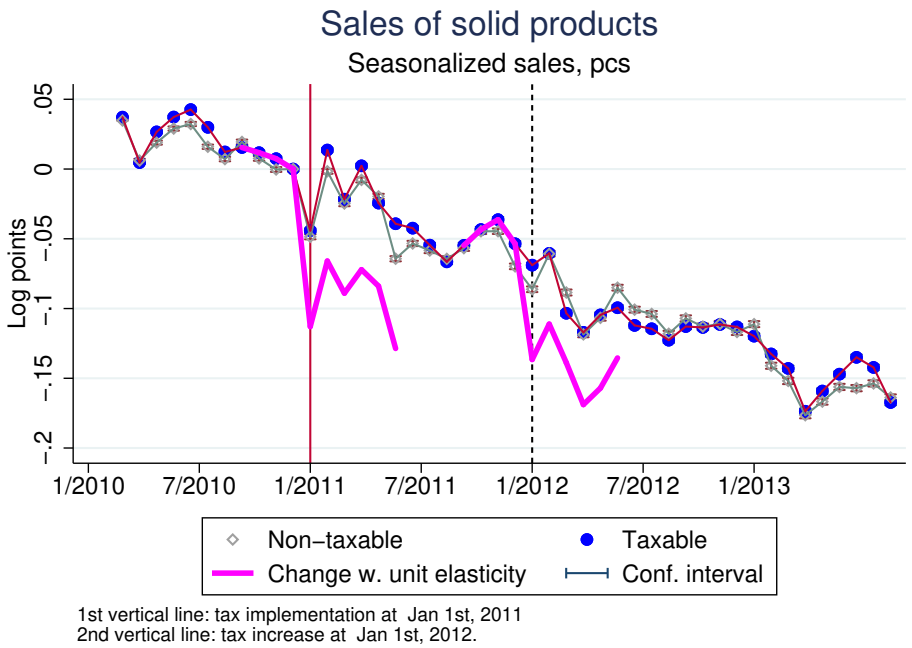
Note: The figure shows regression coefficients for week dummies from regressions of log unit prices with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Mechanical full pass-through in solid pink line shows how taxable product prices would have developed with full pass-through of tax to prices, had they otherwise followed the prices of non-taxable products post-reform. Vertical line is the 2017 abolishment of the sweets tax. The series are normalized to zero at the last week prior to the 2017 reform.

Figure 4: Development of log unit prices, various sub-categories of taxable products in the 2017 reform



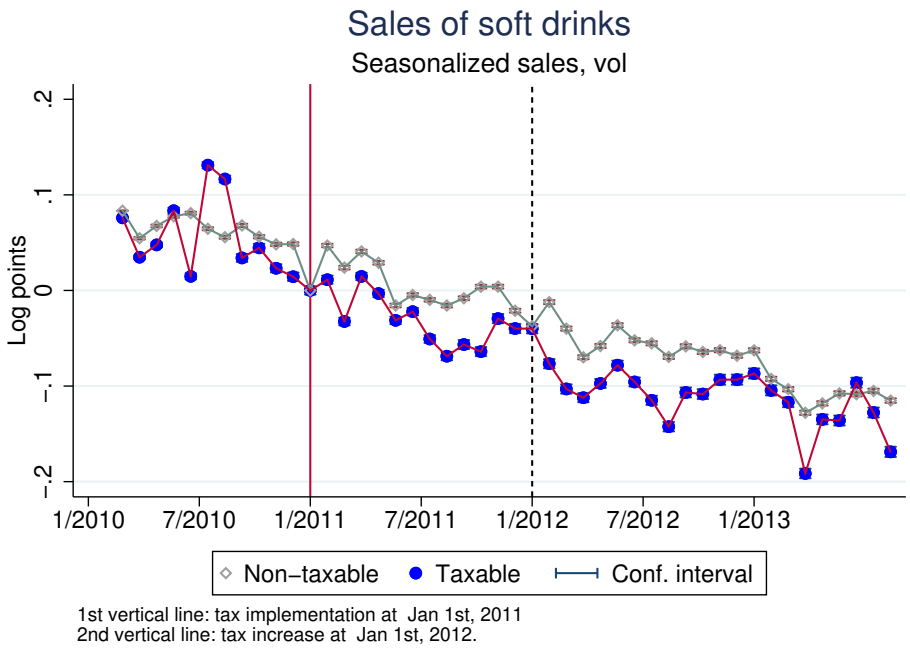
Note: The figures show regression coefficients for week dummies from regressions of log unit prices with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Mechanical full pass-through in solid pink line shows how taxable product prices would have developed with full pass-through of tax to prices, had they otherwise followed the prices of non-taxable products post-reform. Vertical lines is at the 2017 tax abolishment. The series are normalized to zero at one week prior to 2017 reform.

Figure 5: Development of quantities, solid products in the 2011 and 2012 reforms



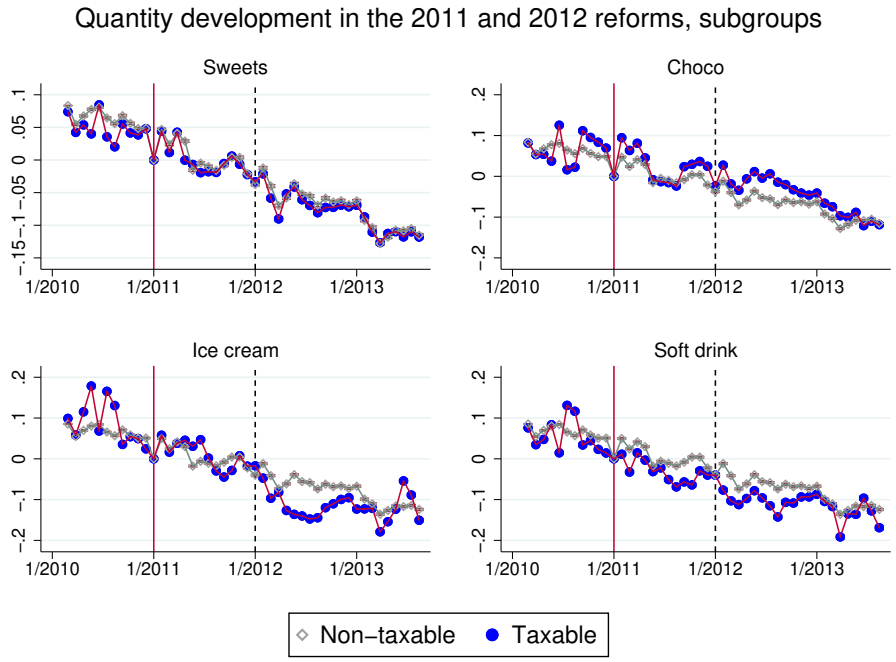
Note: The figure shows regression coefficients for month dummies from regressions of log number of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Change with unit elasticity in solid pink line shows how sold quantities of the taxable products would have developed with unit elasticity, had they otherwise followed the quantities of non-taxable products post-reform. Vertical line is the 2017 abolishment of the sweets tax. The series are normalized to zero at the last week prior to the 2017 reform.

Figure 6: Development of sold volumes, soft drinks in the 2011 and 2012 reforms



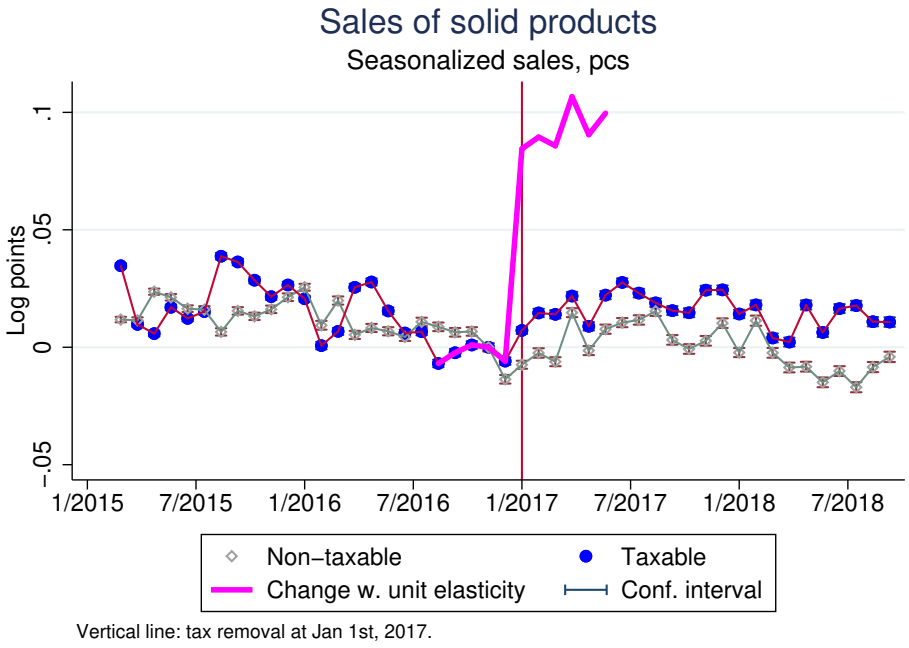
Note: The figure shows regression coefficients for month dummies from regressions of log volume of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Vertical lines are at the 2011 and 2012 reforms. The series are normalized to zero at the last month prior to the 2011 reform.

Figure 7: Development of quantities, various sub-categories of taxable products in the 2011 and 2012 reforms



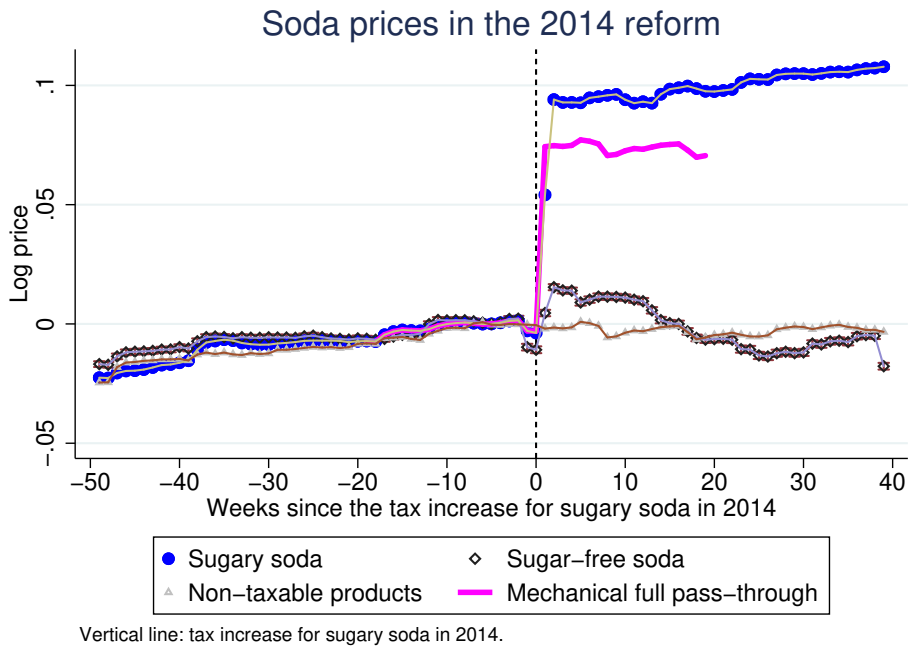
Note: The figure shows regression coefficients for month dummies from regressions of log volume of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Vertical lines are at the 2011 and 2012 reforms. The series are normalized to zero at the last month prior to the 2011 reform.

Figure 8: Development of sold volumes, solid products in the 2017 reform



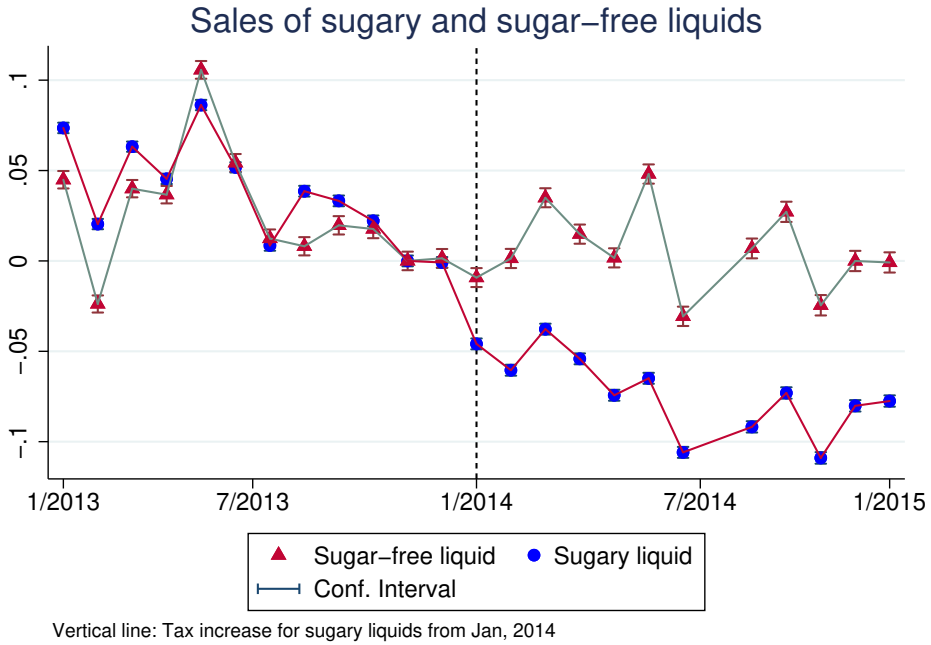
Note: The figure shows regression coefficients for month dummies from regressions of log number of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Change with unit elasticity in solid pink line shows how sold quantities of the taxable products would have developed with unit elasticity, had they otherwise followed the quantities of non-taxable products post-reform. Vertical line is at the 2017 tax abolishment. The series are normalized to zero at two months prior to the 2017 reform.

Figure 9: Development of log soda price by sugar content and comparison prices in the 2014 reform



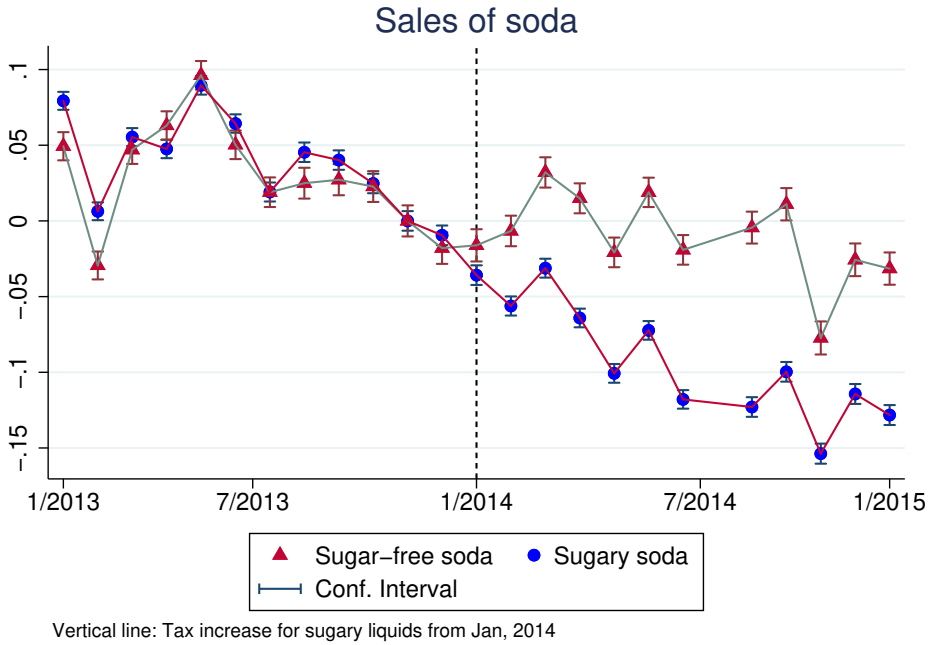
Note: The figure shows regression coefficients for week dummies from regressions of log volume-based prices with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. The comparison group consists of non-taxed solid products (mainly cookies and pastries). Mechanical full pass-through in solid pink line shows how sugary soda prices would have developed with full pass-through of tax to prices, had they otherwise followed the prices of the comparison group post-reform. Vertical line is at the 2014 tax reform. The series are normalized to zero at three weeks prior to the 2014 reform.

Figure 10: Development of sugary vs sugar-free soda sales in the 2014 reform



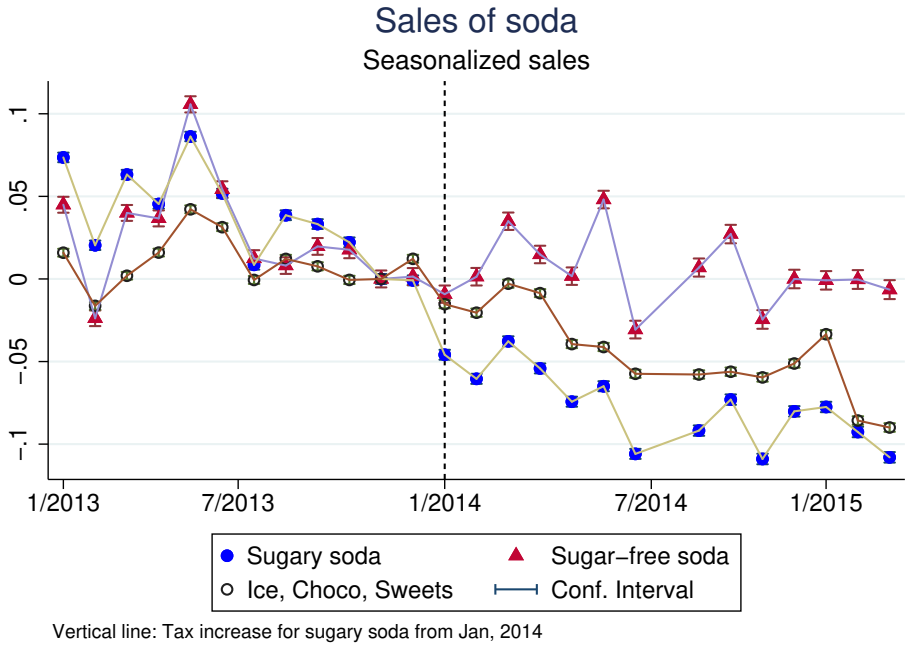
Note: The figure shows regression coefficients for month dummies from regressions of log volume of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Vertical line is at the 2014 reform. The series are normalized to zero at one month prior to the 2014 reform.

Figure 11: Development of sugary vs sugar-free soda sales in the 2014 reform



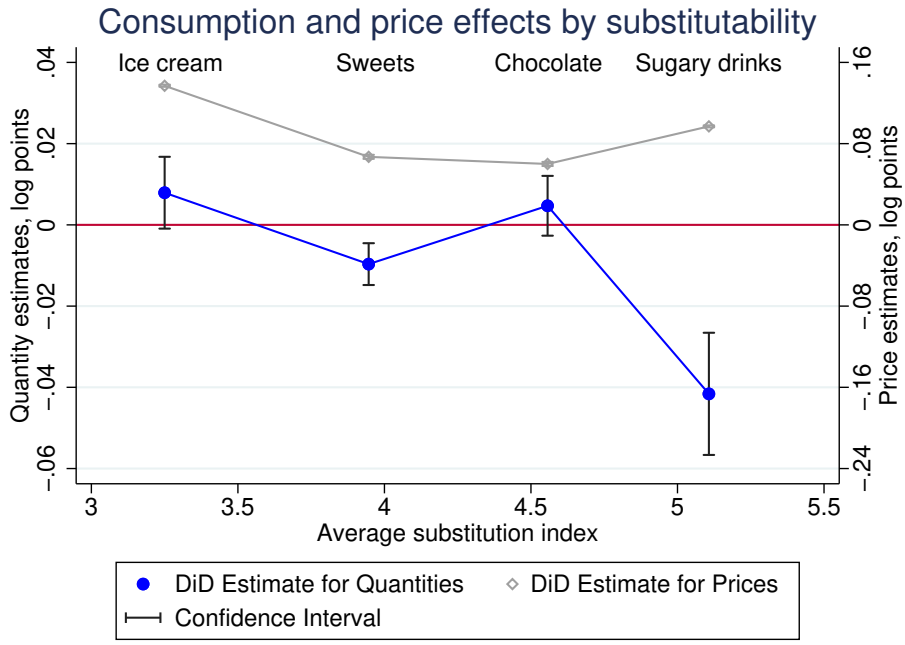
Note: The figure shows regression coefficients for month dummies from regressions of log volume of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Vertical line is at the 2014 reform. The series are normalized to zero at two months prior to the 2014 reform.

Figure 12: Development of sugary vs sugar-free soda vs common control group sales in the 2014 reform



Note: The figure shows regression coefficients for month dummies from regressions of log volume of products sold with product-outlet fixed effects (estimates of equation (2)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the product-outlet level. Vertical line is at the 2014 reform. The series are normalized to zero at two months prior to 2014 reform.

Figure 13: The consumption effects organized by the substitutability between different products



Note: The figure shows subgroup-level DiD estimates of log consumption in the left vertical axis and price responses in the right vertical axis to the tax reforms by four product categories subject to a sweets tax increase: Ice creams, Sweets, Chocolates and Sugary drinks. These come from DiD regressions of log outcomes with product-outlet fixed-effects and month-dummies (estimates of equation (3)). The figure includes 95% confidence intervals surrounding the coefficients based on standard errors that are clustered at the regional branch level. On the x-axis, the estimates are organized by an average index of substitutability based on survey results. The higher this index is, the more substitutable are the products in the category on average with products in their closest non-taxed category. E.g. sugary drinks were seen as more substitutable with non-sugared drinks than chocolates with cookies and sweet pastries. Note that only the estimate for sugary drinks deviates from zero in statistical and economically significant manner.

Tables

Table 1: Descriptive statistics by tax status

				Prices		
	Stat	Price	Pieces	Sweets	Ice	Drinks
Tax	Mean	1.89	11.73	1.86	2.62	1.99
	SD	1.31	28.75	1.51	1.57	1.12
	N	2.22e+08	2.22e+08	5.42e+07	3.74e+07	2.68e+07
	N*pieces	2.60e+09	2.60e+09	6.37e+08	3.17e+08	3.85e+08
	Products*stores	2.29e+06	2.29e+06			
Non-tax	Mean	2.64	9.90			
	SD	2.21	57.99			
	N	9.04e+07	9.04e+07			
	N*pieces	8.95e+08	8.95e+08			
	Products*stores	1.01e+06	1.01e+06			

Note: The table shows descriptive statistics for our main data. Prices are in euros and Pieces are number of sold products per week. Tax refers to the to tax liable products, non-tax refers to non-taxed products in our data. The statistics are for the whole data. Mean indicates the average and SD the standard deviation. N refers to total number of observations in weekly level data. N*pieces refers to the total number of sold products are behind the data by multiplying the number of observations with the number of times the products are sold per week. Products*stores refers to the number of different products multiplied by number of different outlets in our data.

Table 2: Difference-in-difference estimates for the 2011 tax introduction: prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sample	All	All	Kg	Sweets	Chocolate	Ice cream	Soda
DiD	0.077***	0.072***	0.083***	0.067***	0.060***	0.137***	0.043***
	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Tax dummy	-0.492***						
	(0.008)						
Full pass-thr.		0.062	0.087	0.064	0.067	0.150	0.025
N	96,952,759	96,952,759	68,413,067	43,200,452	33,741,918	37,331,691	33,605,331
R^2	0.091	0.992	0.993	0.994	0.996	0.990	0.994
Product fe		X	X	X	X	X	X

Note: The table shows regression coefficients for DiD indicators of the 2011 tax reform from regressions of log unit prices with product-outlet and week fixed effects (estimates of equation (3)). The volume price is kg/l based. The non-taxed group in the regressions consists of all the untaxed products (mainly cookies and pastries). The regressions include only the observations from 2010 and 2011. Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Difference-in-difference estimates for the 2012 tax increase: prices

Vars	(1) All	(2) All	(3) Kg	(4) Sweets	(5) Chocolate	(6) Ice cream	(7) Soda
DiD	0.045***	0.047***	0.042***	0.041***	0.039***	0.034***	0.058***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Tax dummy	-0.411***						
	(0.007)						
Full pass-thr.		0.023	0.020	0.015	0.015	0.033	0.021
N	93,736,671	93,736,671	65,322,911	40,699,710	32,395,559	35,392,988	32,222,605
R^2	0.067	0.994	0.995	0.996	0.997	0.992	0.995
Product fe		X	X	X	X	X	X

Note: The table shows regression coefficients for DiD indicators of the 2012 tax reform from regressions of log unit prices with product-outlet and week fixed effects (estimates of equation (3)). The volume price is kg/l based. The estimates are very close for item prices. The non-taxed group in the regressions consists of all the untaxed products (mainly cookies and pastries) as all the products belonging to the respective categories are tax-liable. The regressions include only the observations from 2011 and 2012. Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Difference-in-difference estimates for the 2011 tax introduction and 2012 tax increase : quantities

VARs	(1) All	(2) All	(3) Sweets
DiD	0.007***	-0.003	0.007*
	(0.002)	(0.002)	(0.003)
Tax dummy	-0.002		
	(0.002)		
N 1,000s	33,388	33,388	22,317
R^2	0.012	0.134	0.137
Product fe		X	X

Note: The table shows regression coefficients for DiD indicators of the 2011 and 2012 tax reforms by having 2010 as the pre-period and 2011-2013 as the post period from regressions of log unit prices with product-outlet and four-week ("month") fixed effects (estimates of equation (3)). The non-taxed group in the regressions consists of all the untaxed solid products (mainly cookies and pastries). Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Difference-in-difference estimates for the 2017 sweets tax abolishment : quantities

VARs	(1) No sweetener	(2) All	(3) Pastr.
DiD	0.011***	0.009***	-0.012*
	(0.002)	(0.002)	(0.007)
N	35,484,478	37,516,839	20,990,392
R^2	0.035	0.036	0.039

Note: The table shows regression coefficients for DiD indicators of the 2017 sweets tax abolishment for sweets and ice cream by having 2016 as the pre-period and 2017 as the post period from regressions of log unit prices with product-outlet and four-week ("month") fixed effects (estimates of equation (3)). The treatment group in all columns are tax liable solids. The control group for the regressions are: (1) non-taxed solids excl. sweeteners, (2) all non-taxed solids, (3) non-taxed sweet pastry. Observations are at the four-week ("month") level and time effects are controlled. Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Difference-in-difference estimates for the 2014 tax increase for sugary drinks on prices

Dep. variable	(1) Sugary drink	(2) Sugar-free drink	(3) Sugary soda	(4) Sugar-free soda
DiD	0.097***	-0.010***	0.075***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Full pass-through	0.081	-	0.074	-
N	51,588,608	36,457,156	34,236,966	30,107,380
R^2	0.992	0.992	0.991	0.992
Product fe	X	X	X	X

The table shows regression coefficients for DiD indicators of the 2014 sweets tax increase for sugary drinks by having 2013 as the pre-period and 2014 as the post period from regressions of log unit prices with product-outlet and week fixed effects (estimates of equation (3)). The taxed group in columns (1) and (2) are all sugary drinks and in columns (3) and (4) sugary soda. The comparison group includes non-taxed solids as well as sweets and ice cream which did not experience any tax changes in 2014. Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Difference-in-difference estimates for the 2014 tax increase on sales

	(1)	(2)	(3)	(4)	(5)	(6)
		Drinks			Soda	
Dep. variable	All	Sugary	Sugar-free	All	Sugary	Sugar-free
DiD	-0.016***	-0.042***	0.053***	-0.041***	-0.073***	0.030***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
N	18,622,752	16,303,592	12,278,244	12,411,675	11,715,429	10,655,871
R^2	0.252	0.250	0.236	0.237	0.235	0.228
Product fe	X	X	X	X	X	X

The table shows regression coefficients for DiD indicators of the 2014 sweets tax increase for sugary drinks by having 2013 as the pre-period and 2014 as the post period from regressions of log number of products sold per month with product-outlet and four-week ("month") fixed effects (estimates of equation (3)). The treatment group in column (1) is all drinks, in column (2) sugary drinks, in column (3) sugar-free drinks, in column (4) all soda, in column (5) sugary soda and in column (6) sugar-free soda. The comparison group includes non-taxed solids as well as sweets and ice cream which did not experience any tax changes in 2014. Standard errors are clustered at the product-outlet level. *** p<0.01, ** p<0.05, * p<0.1

APPENDIX

Figure A.1: Example of the substitution survey